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Income Distribution, Technical Change and the Dynamics of International Economic Integration

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Abstract

This paper explores the features of a dynamic multisectoral model which focuses on the relationship between income distribution, growth and international specialization. The model is explored both for the steady-state properties and the transitory dynamics of integrated economies. Income inequality affects the patterns of growth and international specialization as the model uses non-linear Engel curves and hence different income groups are characterized by different expenditure patterns. At the same time income distribution is also reflected in the relative wage rates of skilled to unskilled workers, i.e. the skill premium, and hence the wage structure affects comparative costs of industries which have different skill intensities. The model is applied to a situation which analyses qualitatively different economic development strategies of catching-up economies (a 'Latin American' scenario and a 'South East Asian' scenario).

Keywords: income distribution, growth, international economic integration, catching-up, international specialization

JEL classification: F15, F16, F43, O15, O41

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1 Introduction

There has been a long and unresolved debate on the effects of trade liberalization and (trade-induced) technical change on wage structures and income distributions of economies. This debate has focused, first, on the effects observed in economically advanced countries (with less emphasis on the developing and catching-up countries) and, second, on the distinction between the effects of trade versus the effects of (skill-biased) technical progress. Over time a consensus seems to have emerged that the standard Heckscher-Ohlin framework must be rejected in order to explain the global rise in wage and income inequalities; this is for theoretical reasons (the effect of technical progress on relative wage rates is not determined and depends on functional specifications and parameter values) and for empirical reasons (i.e. the data do not fit the predictions of the model). For alternative and recent contributions see Haskel and Slaughter (2002), Dinopolous et al. (2001), Trefler and Zhu (2000), Zhu and Trefler (2003), Feenstra and Hanson (2001) and Neary (2003). Although these contributions go beyond the limitations of the standard Heckscher-Ohlin model, two aspects are still underrepresented: First, in all contributions homothetic preferences are assumed such that income distribution does not affect the structure of the economy and trade patterns. Second, the models conduct only comparative-static analyses (i.e. before and after trade integration, before and after a technological 'shock') without analysing the dynamics between the steady states.

Both these aspects are dealt with in the model presented in this paper: The model builds on a classical multisectoral framework and allows for the introduction of income distribution via non-linear Engel curves and substitution between skilled and unskilled workers. Transitory dynamical issues are studied by explicitly introducing adjustment dynamics of prices to costs and wage rate dynamics which depend on skill-specific unemployment rates and bargaining power. We build on our recent work (see Landesmann and Stehrer, 2004; Stehrer, 2002) which introduced a dynamic multisectoral model for a number of countries and skill-types of workers. In an integrated equilibrium the model preserves the properties of a standard dynamic input-output model (i.e. the growth rate depends on the mark-up rate, growth is balanced, etc.). Further the output structure of the integrated economies is determined by the global structure of consumption demand, the structure of demand for intermediate inputs (i.e. international sourcing) and relative patterns of specialization.

From a modelling point of view we generalize the framework used in Landesmann and Stehrer (2004) in two ways: First, the structure of consumption demand (which had earlier used a simple Cobb-Douglas demand specification) is now made dependent also on real income levels (i.e. the model allows for non-linear Engel curve effects). As wage rates differ across skill-types of workers and real income levels also depend on the distribution between wages, profits and rent income, income distribution becomes an important determinant of the output structure of the economies. For internationally integrated economies the output structures of economies are then also dependent on the income levels and distributional patterns of trading partners. The second generalization in the recent version of the model refers to substitution effects between (skill-types of) workers dependent on relative wage rates. Depending on types of technical progress and the strength of these substitution effects together with the elasticity of (relative) skill supply, changes in the skill composition of the (employed) labour force are determined and this in turn has an impact on demand structures (see first point above).

In section 2 we describe a particular application of this model which will then be fully explored in the simulations (section 4). In particular we focus on the relationship between income distribution and specialization patterns of catching-up economies. In section 3 the model is presented and the equilibrium (steady-state) properties are explored. In section 4 we analyse the transitory dynamics of the model (mainly using simulation studies). In these simulation studies we apply the model to shed light on the issues discussed in section 2, i.e. the relation between income distribution, specialization and the growth of catching-up economies.

2 Income distribution and international specialization

In the application of our model we shall explore the following scenarios: We mainly focus on policy options of catching-up economies, i.e. economies which are in the process of closing their productivity (and aggregate real income) gaps relative to more advanced economies. In particular, we shall distinguish two scenarios: one - which we shall call the 'Latin American scenario (LA)' - in which the catching-up process is characterized by a relatively unequal distribution of income and another - which we shall call the 'East Asian scenario (EA)' - in which the distribution of income is less unequal and in which there is also an attempt to improve the skill structure of the (available) labour force (see e.g. the Korean experience).

In fact, we shall show that there will be a type of 'Kuznets curve' emerging, not as a relationship between overall growth and a measure of the degree of income inequality, but between income inequality and the qualitative upgrading of a country's industrial output structure.

Let us describe these relationships and scenarios in more detail: when we speak of qualitative upgrading of a catching-up economy's industrial structure, we mean a shift in output composition towards the industry(ies) in which the productivity (and hence knowledge) gap is initially the largest (these are also likely to be the higher-tech industries, which in our model also correspond to the skill-intensive industries). We shall also specify the final demand structure in such a way that the Engel curves indicate a shift of final demand structures with higher real incomes towards the industries with the larger initial knowledge gap. How then can a catching-up economy shift its output structure towards the industry(ies) with the largest initial knowledge gaps? There are two options: either (1) by targeting export markets which are characterized by high real incomes, or (2) by targeting domestic market segments with relatively high incomes.

Option (1) could in turn be feasible with two types of policies: (1a) Supporting differentially the export industries with the largest initial knowledge gaps through cost-reducing policies even in the phase in which their relative productivity position does not indicate a comparative advantage of the catching-up economy in these industries: such policies include subsidies in a number of forms and preferential (i.e. cheaper) access to the skilled segments of the labour force. (1b) Attempting to close the productivity (knowledge) gaps in those industries as soon as possible. This includes targeting industrial/training policies in a focussed manner on the industries with the largest knowledge gaps, including the fast build-up of those 'endowments' which are specifically required as inputs for these industries (again, skilled labour, managerial, R&D, export and marketing capacities).

The difference between options (1a) and (1b) is that (1a) also allows successes of export policies in the short run but may not be compatible with a non-discriminatory trade regime, while (1b) is based on turning around comparative advantage positions in industries in which the initial knowledge gap is large, which is a strategy that requires time - but is compatible with a liberal trading regime (in fact it may also greatly benefit from encouraging FDI, which can act as an agent which bridges the initial knowledge gaps).

Option (2) requires the availability of a high real income segment in the catching-up, i.e. poorer, economy and the ability of domestic industries which have not achieved a comparative advantage position in these industries to capture this segment rather than importers. Since comparative advantage has not been achieved by the catching-up economy in these industries, the strategy requires some sort of explicit or implicit form of protection. We shall introduce this type of policy in the form of a 'home market bias' by domestic consumers, but an explicit introduction of tariffs or quota restrictions would also be a possible scenario. Option 2 clearly benefits initially from a more unequal distribution of income, as this supplies - in an overall poor economy - a class of consumers with relatively high incomes.

How does this add up to a 'Kuznets-type relationship' between income inequality and qualitative upgrading of industrial structures? Option (2) allows a poorer economy to develop a market segment within a country for industries in which the country has a large initial knowledge gap and would therefore not have a comparative advantage. Hence at an overall low level of incomes, an unequal distribution of incomes would provide some industries with a large knowledge gap with a domestic market. In our model specification, however, unequal distribution of income is specified in terms of relatively high incomes of skilled workers compared to unskilled workers and this does not improve the comparative cost position of those industries which require a relatively higher input of skilled labour. Hence, in this scenario, the capturing of the domestic market segment does not rely on comparative cost advantage but purely on protection (including home market bias effects).

Both options (1a) and (1b) on the other hand are designed to make those inputs cheaper which are relatively needed in the industries with the larger knowledge gap. This implies in particular relatively cheap skilled labour and hence requires low income inequality between skilled and unskilled workers. This can be obtained either through subsidies or, in the context of a non-discriminatory trading system, by having low bargaining strength of skilled workers and/or a policy which increases the relative supply of skilled workers. As comparative advantage does not shift immediately, this policy will shift the output structure towards industries with the higher knowledge gaps only over the longer-run. Hence we obtain the shape of the modified Kuznets curve: initially there will be an advantage of option (2) to shift the output structure towards industries with higher knowledge gaps; over time, however, this strategy has limitations in terms of the size of the domestic market and, in particular, the size of the high real income segment in the domestic market. Option (1b) truly shifts comparative advantage towards industries in which the higher knowledge (and skill) gap exists and does not suffer from the size restrictions of the (high real income segment) in the domestic market; in fact, once comparative disadvantage disappears in these industries, a liberalised trade regime will allow the catching-up economy to do well on both domestic and export markets. Hence output structures can shift further towards industries with the higher initial knowledge gaps than under policy option (2); see figure 2.1[1]. The above analysis gets more complicated once

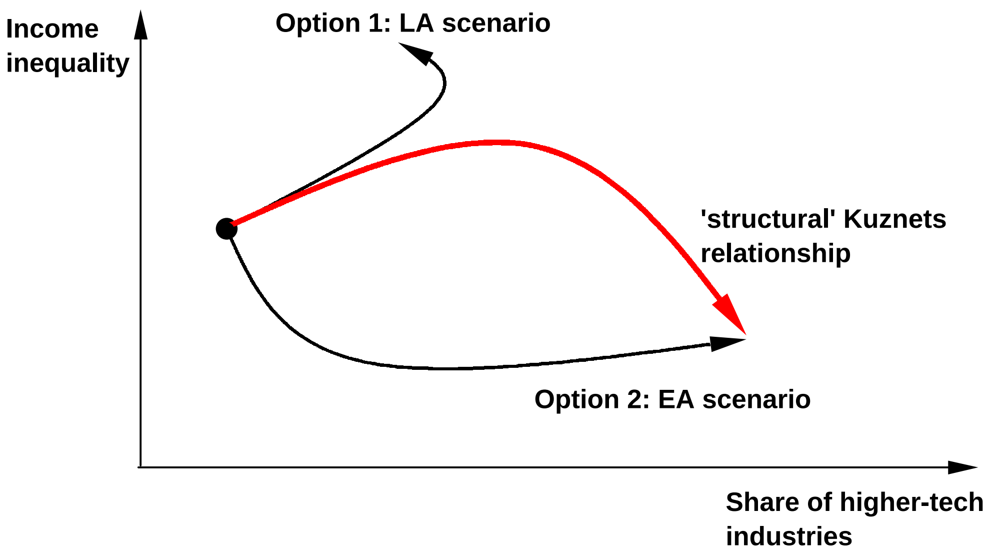


Figure 2.1: 'Modified' Kuznets relationship

we allow for mechanisms which endogenise rates of productivity catching-up (either as a function of production experience or the presence of foreign investors) and/or the impact of different output compositions (in terms of high- or low productivity growth industries) on the overall growth rate of the economy, as well as of different distributions of incomes between wages and rents.

[1]Higher-tech industries are defined as those industries which have a higher skill-intensity. We shall assume that in these industries the catching-up economy has the higher initial knowledge gap. The measure of income inequality which we shall focus on in this paper will be the relative wage rate of skilled to unskilled labour, i.e. the skill premium.

The lines (option 1, option 2 and 'modified' Kuznets curve) refer in a stylized manner to the strategies discussed in the text.

3 Modelling the dynamics of integrated economies

In this section we present the detailed structure of the model, which is then used in the simulation studies.

3.1 Technology

3.1.1 Technology matrix and international sourcing of intermediates

We start with a matrix of technical input coefficients for each country c, denoted by $\tilde{\mathbf{A}}^{\mathbf{c}} = \begin{pmatrix} \tilde{\mathbf{a}}^c_{*1} & \dots & \tilde{\mathbf{a}}^c_{*i} & \dots & \tilde{\mathbf{a}}^c_{*N} \end{pmatrix}$ where $\tilde{\mathbf{a}}^c_{*i} = \begin{pmatrix} \tilde{a}^c_{1i} & \dots & \tilde{a}^c_{ji} & \dots & \tilde{a}^c_{ni} \end{pmatrix}^\top$. A typical element $\tilde{a}^c_{ji}$ denotes a *technical* input coefficient of sector i in country c. These technical coefficients are assumed to be stable over time (i.e. determined by technological considerations). The technical coefficients must be distinguished from the demand matrix for intermediate inputs as goods may be purchased from different suppliers; we shall refer to this demand matrix as the 'sourcing matrix'; the elements of that matrix will be price-sensitive as we shall allow for substitution (as well as for potential 'home' and 'regional bias') effects. We denote the demand coefficients for intermediate inputs supplied by country c to country r as

$$\mathbf{A}^{\mathbf{cr}} = \begin{pmatrix} a^{cr}_{11} & \dots & a^{cr}_{1N} \\ \vdots & \ddots & \vdots \\ a^{cr}_{N1} & \dots & a^{cr}_{NN} \end{pmatrix}.$$

These demand (or 'sourcing') coefficients have to satisfy the technologically given constraint $\tilde{a}^r_{ji} = \sum_c a^{cr}_{ji}$. The overall world sourcing matrix is then given by

$$\mathbf{A} = \begin{pmatrix} \mathbf{A}^{11} & \dots & \mathbf{A}^{1C} \\ \vdots & \ddots & \vdots \\ \mathbf{A}^{C1} & \dots & \mathbf{A}^{CC} \end{pmatrix}.$$

The global sourcing matrix $\mathbf{A}$ is assumed to satisfy the conditions to guarantee economically meaningful solutions (see e.g. Gale, 1960).

3.1.2 Input of labour

Demand for labour arises from cost-minimizing behaviour of firms with respect to a CES production function (we only include labour as inputs as there is no substitution between types of workers and intermediate inputs). This CES production function is denoted by

$$q^c_i = A^c_{l,i} \left(\sum_z \alpha^c_{l,iz} (a^c_{l,iz} l^c_{iz})^{\rho^c_{l,i}} \right)^{1/\rho^c_{l,i}}$$

where $z = 1, \dots, Z$ are different skill-types of workers. We assume that $\sum_z \alpha^c_{l,iz} = 1$. For $\rho^c_{l,i} \to 0$ the function becomes the usual Cobb-Douglas production function given by $q^c_i = A^c_{l,i} \prod_z (a^c_{l,iz} l^c_{iz})^{\alpha^c_{l,iz}}$. Under the assumption of cost-minimization and industry- and skill-specific wage rates w^c_{iz} the labour input coefficients can be derived, which are denoted by $\tilde{\mathbf{a}}^c_{l,i} = \begin{pmatrix} \tilde{a}^c_{l,i1} & \dots & \tilde{a}^c_{l,iZ} \end{pmatrix}$.

Technical progress can take a variety of forms by changing parameter values in the production function. In this paper we assume two different forms of technical progress. First, an increase in the parameter A^c_i increases total factor productivity and is Hicks-neutral. This allows to introduce sector-biased technical change. Second, we assume that there can be shifts in the share parameters $\alpha^c_{l,iz}$. An increase in the share of skilled workers implies that production technology becomes more skill-intensive. At constant relative factor prices this implies that production becomes more skill intensive and thus - as skilled workers are relatively more expensive than unskilled - this would increase costs. This form of technical progress must therefore be accompanied by an increase in total factor productivity so that cost-minimization in the choice of techniques is not violated. This form of technical progress is skill using in the Hicksian sense; it is not factor-augmenting technical progress which would correspond to a shift in the parameters $a^c_{l,iz}$.

3.2 Prices and rents

The price dynamics is modelled as adjustment to unit costs using a differential equation

$$\dot{p}^c_i = -\delta^c_{p_i} \left[p^c_i - (1 + \pi^c_i) c^c_i \right]. \tag{1}$$

$c^c_i = \sum_j p^c_j a^c_{ji} + v^c_i$ are the costs of production and $v^c_i = \sum_z w^c_{i,z} \tilde{a}^c_{li,z}$ denote the unit labour costs in a particular sector i and country c. We assume that wage rates (by skill-types) $w^c_{i,z}$ need not be equal across sectors, although we shall assume that wage rates for each particular skill-group tend to equalize in the long run as we shall see below. The parameter $0 < \delta^c_{p_i} \leq 1$ represents the speed of adjustment of prices to (equilibrium) unit labour costs. As there is a constant long-run mark-up ratio on prices π^c_i there are long-run per unit profits (mark-up) $m^c_i = \pi^c_i c^c_i$. As prices do not adjust immediately to unit costs plus a (long-run) mark-up, there arise *transitory rents* $r^c_i = p^c_i - (1 + \pi^c_i) c^c_i$ depending on the speed of technological progress, the price-to-cost adjustment parameter and the dynamics of wages as we shall see below.

3.3 Labour market

Nominal wages are growing or falling for three reasons: First, transitory rents are partly distributed to workers; second, excess supply (demand) of workers in the labour market drives wages up or down; and third, we assume skill-specific wage equalization across sectors in the long run. These three factors are formalized as follows:

$$\dot{w}^c_{iz} = \kappa^c_{r,iz} \frac{r^c_i}{\sum_z \tilde{a}^c_{l,iz}} + \kappa^c_{u,z} u^c_z w^c_{iz} + \kappa^c_{w,z} \frac{w^c_{iz} - \bar{w}^c_z}{w^c_{iz}} \tag{2}$$

with $\kappa^c_{r,iz} = \kappa^c_{s,i} w^c_{iz} / \sum_z w^c_{iz}$. $0 \leq \kappa^c_{r,i} \leq 1$ is the proportion of per unit (transitory) rents r^c_i paid to workers (bargaining coefficient). The specification of the first term on the rhs of the wage equation implies that wage rates of different types of workers are absorbing a certain proportion of sector-specific rents (the latter are defined per unit of output). This means that wage rates can (temporarily) be different across sectors and skill groups as rents are, in the first instance, distributed only to workers in the respective sector where the rents arise.

The second term on the rhs of the wage dynamics equation reflects the impact of unemployment on the dynamics of the wage rates ($\kappa_{u,z}^c \leq 0$). The skill-specific unemployment rate is defined as $u_z^c = (h_z^c - \sum_i l_{iz}^c)/h_z^c$ where h_z^c and l_{iz}^c denote labour supply and demand, respectively.

Third, there is an impact on the wage dynamics if wage rates (for the same skill-type of worker) differ across sectors. This reflects the common assumption that wage rates become equalized across sectors because of labour mobility. The (weighted) average wage rate (across sectors) is defined as $\bar{w}_z^c = \sum_i l_{iz}^c w_{iz}^c / \sum_i l_{iz}^c$. If the average wage $\bar{w}_z^c$ is higher than the sectoral wage w_{iz}^c the wage in sector i will rise, in the other case fall. This term works across all sectors. Thus in the formulation used in the simulations, there are two sector-specific terms and one economy-wide term having an influence on wage rates in each sector. Skill-specific wage differentiation can occur across sectors in the short run, but wage rates are equalized for the same skill group across sectors in the long run.

Labour demand is determined by labour input $\tilde{a}_{l,iz}^c$ and the levels of output. Skill-specific labour supply h_z^c is exogenously given. In the simulations we allow for exogenous changes in labour supply given by

$$\dot{h}_z^c = \left[\left(1 - \frac{h_{0z}^c - \bar{h}_z^c}{h_{0z}^c} \right) h_{z,pot}^c h_{0z}^c - h_z^c \right] \tag{3}$$

where h_{0z}^c denotes the starting level of supply, $\bar{h}_z^c$ is the final level of supply and $h_{z,pot}^c$ is assumed to follow an exogenously given logistic curve. The second term in equation 3, which is used in the simulations, refers to changes in (relative) endowments. The formulation keeps the endowment with labour $\sum_z h_z^c$ constant and allows for catching up of relative endowments to e.g. the reference country as $\bar{h}_z^c = (h_z^1 / \sum_z h_z^1) \sum_z h_z^c$ where 1 denotes the reference country.

In equilibrium with no technical progress in which the economy is growing at a constant rate γ_q the growth rate of each type of labour must be $\gamma_z^c = \gamma_q$. (Of course, the maximum of the work force cannot exceed the stock of this skill-type in the population times a long-term participation rate.)

3.4 Quantities: Demand components

Following on from the discussion of the price system, the quantity system must be specified. Demand for goods consists of three different components which can be summarized in the following demand equations:

$$q_i^c = \sum_{r,j} a_{ij}^{cr} q_j^r + j_i^c + f_i^c. \tag{4}$$

The first term is demand for intermediate goods used in production, the second term is (net) investment demand (financed - by assumption - out of profit and rent income) and the third term reflects consumption demand (at this stage assumed to come from workers' incomes). j_i^c and f_i^c therefore denote investment and consumption demand respectively for good i. We discuss each of these items in turn.

3.4.1 Demand for intermediate inputs and the 'global sourcing' matrix

The quantity of intermediate inputs to be purchased in one period of production is $\mathbf{a}_{*j}^{*r} q_j^r$; its nominal value is $\mathbf{p}^\top \mathbf{a}_{*j}^{*r} q_j^r$. These intermediate inputs can be purchased from countries c and hence the nominal share (of total outlays on intermediate goods) spent by a sector j located in country r on an intermediate good i from country c is given by $\beta_{A,ij}^{cr} = p_i^c a_{ij}^{cr} / \mathbf{p}^\top \mathbf{a}_{*j}^{*r}$ where the (sourcing) coefficients a_{ij}^{cr} are momentarily given, but are themselves dependent on prices and may thus vary over time as we shall see below. The constraint is given by $\sum_c a_{ij}^{cr} = \tilde{a}_{ij}^r$, i.e. the sourcing coefficients of intermediate inputs must sum up to $\tilde{a}_{ji}^r$, the technical input coefficient for input i in sector j of country r (see also section 3.1 above).

We apply the following modelling strategy: The (physical) amount of input i necessary per unit of output j in country r is given by $\tilde{a}_{ij}^r$. This input can be sourced from different countries c. Let us denote these shares by ζ_{ij}^{cr} with $\sum_c \zeta_{ij}^{cr} = 1$. The physical amount is thus $\zeta_{ij}^{1r} \tilde{a}_{ij}^r + \cdots + \zeta_{ij}^{Cr} \tilde{a}_{ij}^r$. We denote these physical quantities by a_{ij}^{cr}, i.e. the elements of the sourcing matrix $\mathbf{A}$.

How are the shares ζ_{ij}^{rc} determined? According to a CES specification we use the following expression:

$$\zeta_{ij}^{cr} = (p_i^c)^{1-\sigma_{A,ij}^r} (\alpha_{A,ij}^{cr})^{\sigma_{A,ij}^r} \left(\sum_s (p_i^s)^{1-\sigma_{A,ij}^r} (\alpha_{A,ij}^{sr})^{\sigma_{A,ij}^r} \right)^{-1} .$$

We shall assume that the goods purchased in different countries are substitutes or $\sigma_{A,ij}^r > 1$. As a special case $\sigma_{A,ij}^r = 1$ and the expression becomes $\zeta_{ij}^{cr} = \alpha_{A,ij}^{cr}$ which implies a constant sourcing matrix.

Whereas $\sigma_{A,ij}^r$ is the same across (supplier) countries, the parameter $\alpha_{A,ij}^{cr}$ gives weights to different countries c which may differ for sectors i and j. This parameter reflects a 'suppliers bias' (it can be used e.g. to include a 'home bias' or a 'regionalist bias' effect) or can also be used to reflect trade barriers. This formulation satisfies the condition that $\sum_c \zeta_{ij}^{cr} = 1$. Setting $a_{ij}^{cr} = \zeta_{ij}^{cr} \tilde{a}_{ij}^r$ gives the coefficients of the $\mathbf{A}$ matrix which satisfy $\sum_c \zeta_{ij}^{cr} \tilde{a}_{ij}^r = \sum_c a_{ij}^{cr} = \tilde{a}_{ij}^r$. These coefficients give the structure of purchases of intermediate input goods across countries and sectors and thus define the 'global sourcing matrix' $\mathbf{A}$ introduced in subsection 3.1 above.

The second step is to calculate the quantity of goods i in country c purchased by sector j of country r. For determined sourcing coefficients a_{ij}^{cr} this is determined by $(1/p_i^c) \beta_{A,ij}^{cr} \mathbf{p}^\top \mathbf{a}_{*j}^{*r} q_j^r = a_{ij}^{cr} q_j^r$ which refers to demand for good i in country c bought by sector j in country r which produces q_j^r.

Summing up over countries r and sectors j gives the total demand for intermediate inputs in sector i of country c. Thus the first component in the demand equation (4) is $\sum_{r,j} a_{ij}^{cr} q_j^r$.

This formulation allows for substitution across countries when buying intermediate inputs. Note that this implies that a higher physical amount of intermediate inputs can be purchased as expenditures are allocated more efficiently over countries; or, alternatively, the same bundle of technologically determined inputs can be purchased at lower costs as expenditures are allocated more efficiently over countries.

3.4.2 Investment demand

Next we specify how income out of retained earnings is spent. We assume that per unit profits and rents which are not distributed to workers, i.e. $s_k^s = \big((1-\kappa_{r,k}^s)r_k^s + m_k^s\big)$ are entirely used for investment. Total rents plus profits in nominal terms in the economy s and sector i are then given by $s_k^s q_k^s = \big((1-\kappa_{r,k}^s)r_k^s + m_k^s\big)q_k^s$. In an integrated economy investors have to make two decisions: First, in which country and sector to invest, and second, in which country to buy the goods for investment. These questions are guided by different considerations: the first one is motivated by relative per unit rents (and profits), the second by relative prices for purchases of investment goods.

The first question was addressed in Landesmann and Stehrer (2004). In this paper we assume that investment takes place only in the specific sector and country in which rents are arising.[2] The invested sum has to be allocated across components for intermediate inputs and demand for workers. Analogously to the above the invested sum has to be allocated according to

$$\beta_{J,ij}^{cr} = \frac{p_i^c a_{ij}^{cr}}{\mathbf{p}^\top \mathbf{a}_{*j}^{*r} + v_j^r} \qquad \text{and} \qquad \beta_{L,j}^{r} = \frac{w_{j,z}^r a_{l,jz}^r}{\mathbf{p}^\top \mathbf{a}_{*j}^{*r} + v_j^r}.$$

The first term refers to the allocation of nominal investment across intermediate inputs and the second term to demand for different skill-types of workers. Investment demand in sector i of country c is thus given by

$$j_i^c = \frac{1}{p_i^c} \sum_{r,j} \beta_{J,ij}^{cr} s_j^r q_j^r$$

which is the second component in the demand equation (4).

3.4.3 Consumption demand

A typical worker receives nominal income given by his wage rate $y_{jz}^r = w_{jz}^r + \kappa_{r,jz}^r r_j^r / \sum_z \tilde{a}_{l,jz}^r$ where the second term results from bargaining of workers over rents. Expenditures are allocated across goods i and within these goods across countries c in a two-stage budgeting

[2]As will be explored below, this requires that the mark-up ratios π_i^c must be equal across countries and sectors, i.e. $\pi_i^c = \pi, \forall i, c$ to guarantee the existence of a balanced equilibrium growth path.

process. For the second stage we assume that expenditure shares are given by (resulting from a CES specification)

$$\gamma_{i,jz}^{cr} = (p_i^c)^{1-\varsigma_i^r} (\beta_i^{cr})^{\varsigma_i^r} \sum_c (p_i^c)^{1-\varsigma_i^r} (b_i^{cr})^{\varsigma_i^r - 1}.$$

The term $\tilde{p}_i^r = \sum_c (p_i^c)^{1-\varsigma_i^r} (\beta_i^{cr})^{\varsigma_i^r}$ can be interpreted as the price of good i in country r. In the first stage expenditures have to be allocated across goods. We assume that individuals in the particular countries have the same preferences. The nominal shares then depend on real income levels and relative prices. For the specification we use a (simplified) formulation derived from an AIM model (formerly known as Almost Ideal Demand System; see Deaton and Muellbauer, 1980):

$$\gamma_{i,jz}^r = \alpha_{AIM,i} + \beta_{AIM,i} \big(\ln y_{jz}^r - \ln \tilde{P}^r \big) + \sum_j \gamma_{AIM,ij} \ln \tilde{p}_j^r$$

with

$$\ln \tilde{P}^r = \alpha_{AIM,0} + \sum_k \alpha_{AIM,k} \ln \tilde{p}_k^r + 0.5 \sum_j \sum_k \gamma_{AIM,kj} \ln \tilde{p}_k^r \ln \tilde{p}_j^r.$$

The nominal expenditure share of a typical worker of skill-type z in country r working in industry j on goods i in country c is then $\mu_{ijz}^{cr} = \gamma_{i,jz}^{cr} \gamma_{i,jz}^r$. As $\sum_c \gamma_{i,jz}^{cr} = 1$ and $\sum_i \gamma_{i,jz}^r = 1$ we also have that $\sum_{i,c} \mu_{ijz}^{cr} = 1$. Summing up over workers of skill-types z employed in sectors j in countries r gives consumption demand for good i in country c, i.e.

$$f_i^c = \frac{1}{p_i^c} \sum_{r,j,z} \left(\mu_{ijz}^{cr} y_{j,z}^r \tilde{a}_{l,jz}^r \right) q_j^r.$$

This is the third term in the demand equation (4).

3.4.4 Existence of solution

The system of equations (4) is homogenous as all components on the rhs depend on q_i^r. Thus one has to show that a nontrivial solution for q_i^r exists. In this way the model differs from a classical input-output model where the final demand vector is given (in quantity terms) and under certain conditions on the input-output matrix an economically meaningful solution exists. Under the assumption of fixed prices (which implies constant wages) the nominal shares discussed above are constant. In this case one can show that a nontrivial solution exists (see Stehrer, 2002). The condition is basically that all income (either rent or wage income) is actually spent. Further note that this result does not assume that prices are at their equilibrium values.

3.5 Output dynamics

Let us now discuss the dynamics of the output system. We first show how the growth rates of the system are calculated; second, we characterize the balanced growth path as a special case and, third, discuss potential demand-supply mismatches.

The nominal sum invested in sector j of country r is given by $s_k^s q_k^s$. The physical increase in capacities is made up of the set of capital goods $k = 1, \ldots, N$. The increase in capacity of the component i in country c derived from additional investment can be calculated as $(1/p_i^c)\beta_{J,ij}^{cr} s_j^r q_j^r$. Inserting for $\beta_{J,ij}^{cr}$, summing up over all countries c and dividing by the existing 'stock' of intermediate inputs gives the growth rate of all components i in sector j

$$g_j^r = \frac{1}{\tilde{a}_{ij}^r q_j^r} \frac{s_j^r q_j^r}{\mathbf{p}^\top \mathbf{a}_{*j}^{*r} + v_j^r} \tilde{a}_{ij}^r = \frac{s_j^r}{c_j^r}. \tag{5}$$

Analogously one can show that demand for labour is growing also at these rates. Thus the derivation of the growth rate guarantees that the increase in capacities (intermediates and labour) would be proportional in all equipment goods i and for all skill-types of workers. Hence, the capacity effect in equipment good i is equivalent to the overall capacity increase in sector j. But still capacity in the particular sectors may grow at different rates. Further the two results above show that switching from one supplier country to another would not change the growth rate if both suppliers have the same price. However, switching to a cheaper supplier results in a higher growth rate as a higher quantity can be purchased. Demand out of workers income spreads across sectors and countries via the demand formula f_i^c given above. Further demand out of rents is growing also at rate g_j^r which spreads over to other sectors via demand arising from these investments. The dynamics of the economy is then given by

$$\dot{\mathbf{q}} = (\mathbf{I} - \mathbf{A})^{-1}(\mathbf{D}_j + \mathbf{D}_f)(\mathbf{I} + \mathbf{G})\mathbf{q} - \mathbf{q} \tag{6}$$

where $\mathbf{D}_j$ denotes a matrix with typical element $(1/p_i^c)\sum_{r,j}\beta_{J,ij}^{cr} s_j^r$ and $\mathbf{D}_f$ denotes a matrix with typical element $(1/p_i^c)\sum_z \left(\mu_{ijz}^{cr} y_{j,z}^r \tilde{a}_{l,jz}^r + \mu_{ijz}^{cr} w_{j,z}^r \tilde{a}_{l,jz}^r g_j^r\right)$.[3] $\mathbf{G}$ denotes a diagonal matrix with the sector-specific growth rates g_j^r on the diagonal.

It can be shown that there exists a balanced growth path. However in the transition there may arise capacity-demand mismatches. These topics are discussed in the appendix.

3.6 Weak and strong Gerschenkron patterns of catching-up

A much discussed aspect of the linkages which emerge from international economic integration is that countries can learn from each other, i.e. that there are 'knowledge spillovers'. This greatly facilitates the catching-up of technologically backward countries with more advanced countries.

The modelling strategy which will be used in this paper is that countries are catching up with the leading country (or the technology frontier). Different paths of catching-up processes were investigated in Landesmann and Stehrer (2001) and this discussion will not be repeated here. In the simulations below we assume that a (technologically) lagging country will experience higher rates of change of the technological parameters in the production function in those industries which start off with a larger initial gap relative

[3]This specifically assumes that the newly hired workers have the same spending patterns (given by μ_{ijz}^{cr}) as the incumbent workers, although the income is lower as they do not receive rents from the wage bargaining process.

to the leader (this amounts to an application of Gerschenkron's famous hypothesis of the 'advantage of backwardness' at the industrial level (Gerschenkron, 1962, 1952); see also Landesmann and Stehrer (2001) for a theoretical discussion and empirical analysis of this use of the Gerschenkron hypothesis). One may also differentiate between a 'weak' and 'strong' Gerschenkron effect. A 'weak' Gerschenkron effect means that catching-up of the industries takes place following the same logistics. This does not imply however that productivity growth is equal as the 'gap' from the frontier matters at each point of time. A 'strong' Gerschenkron effect takes place when the convergence parameter is higher in industries with the larger initial gap. This may even imply a 'switchover in comparative advantage' that can take place in the course of catching-up. Further one may introduce various mechanisms which allow an endogenization of productivity catching-up (as e.g. learning-by-doing or the effects of foreign direct investment). These two issues are explored in Landesmann and Stehrer (2004) in detail.

4 Simulation studies

4.1 Simulation strategy

The application of the model developed in the previous section will focus in this paper on development strategies of different types of catching-up economies: Catching-up economies are those which start off with an initial (total factor) productivity gap compared to advanced economies. Apart from this there is also a difference between advanced and (potential) catching-up economies in the initial factor endowments, in our case in the relative endowments of skilled and unskilled workers.

Catching-up or convergence then refers to two things: catching-up in total factor productivity levels and convergence in relative factor endowments. We shall simulate both these processes of catching-up but will also explore scenarios in which productivity levels do converge but not relative factor endowments (e.g. if there is a lack of a human-capital upgrading policy) or in which the latter converges very slowly. With regard to productivity convergence we shall basically assume a Gerschenkron scenario (discussed earlier) in which the scope for productivity convergence is higher in the industry in which the initial gap is larger[4]. Depending on the relative wage dynamics compared to the productivity dynamics there will be a variety of possibilities how the comparative cost dynamics evolves between the advanced and the catching-up economy.

The focus on catching-up countries will concentrate on two types of 'stylized' development strategies: a 'Latin-American' (LA) strategy and an 'East Asian' (EA) strategy.[5] The Latin American strategy will be characterized by a sustained greater inequality of

[4]For the sake of brevity, we shall call the industry in which the initial productivity (and hence knowledge) gap is larger the 'high-tech' sector.

[5]We do not claim that either all Latin American or South-East Asian countries fit the stylized features presented here or fit them over the relevant stages of development discussed here. The purpose of this stylized presentation is to label the simulation scenarios with names that indicate some of the features usually associated with development strategies in LA and EA respectively.

incomes as compared to South-East Asia. Furthermore, we shall associate with South-East Asia a stronger emphasis of factor endowment convergence with more advanced economies (i.e. a strong attempt to shift the composition of the available labour force towards skilled workers). Finally, we shall explore different scenarios with respect to the degree and duration of overall protection and selective protection of different sectors.

Let us remind the reader of our a priori conjectures with respect to these two types of development scenarios (see also section 2). Both types of economies start off with a relative factor endowment structure which implies a comparative disadvantage in skill-demanding sectors (i.e. sectors in which they initially also have the larger technology i.e. productivity gaps). Given this comparative disadvantage there are two ways to encourage the development of the high-tech industries: one way is to develop and capture the domestic market for these types of goods. This we associate with the LA strategy: what is required here is a relatively uneven distribution of income because this will provide a segment of the domestic market which has high (absolute) real income levels and which - given the non-linear Engel curves assumed in our model - will demand relatively more of the 'high-tech' good. However, as the domestic producers do not have a comparative advantage in producing this good, the domestic market will have to be protected so that the domestic producers can capture this market. Given the way we model inequality of income, i.e. in the form of higher relative wage rates of skilled compared to unskilled workers (i.e. the 'skill premium'), the LA strategy will make the comparative disadvantage position of the high-tech sectors worse, as these sectors require relatively more skilled workers.[6]

The second development strategy scenario - the EA scenario - relies on an attempt to speed up the Gerschenkron pattern of productivity convergence, i.e. to cover the (wider) initial knowledge gap in the high-tech sectors as quickly as possible and also to reduce somewhat the comparative cost disadvantage of these industries through a relatively low inequality in the distribution of income, i.e. a low skill premium. This last factor reduces - in a comparative static context - the shift of domestic demand towards high-tech products (which would be demanded more by those with high real incomes) but benefits the comparative cost dynamics in favour of the high-tech industries. The EA strategy thus stands a better chance than the LA strategy to do better earlier in terms of comparative advantage in the high-tech sectors and hence has to rely less (or at least for a shorter period of time) on domestic market protection to further the development of the high-tech industry sector.

Let us now present an overview of the simulations we shall discuss in the following: The simulations start with uneven initial (total factor) productivity gaps and uneven initial factor endowments between an advanced economy (AC) and the catching-up (CU) economy. Over the long run we postulate in the runs exogenous convergence in productivity levels and relative factor endowments. Differences in the speed of technological convergence compared to convergence in relative factor endowments (given the 'home market

[6] Of course, there is also a large literature on the so-called 'infant industry' argument which relies on the endogenous productivity effects induced by the experience of producing more advanced (high-tech) commodities. We shall return to this later.

bias' or trade barriers) result in different dynamics of comparative advantage, evolution of expenditure patterns, of international production specialization, of skill demands and skill premia in the transition and the long-run steady-state.

As mentioned above we show three scenarios: In the first scenario (LA scenario) we assume a constancy in relative factor endowments which - as we will see below - lead to a higher income inequality. In the second scenario we assume a moderate relative factor endowment convergence process with the stationary home market bias. We assume that the position of the two skill-types of workers in the wage bargaining process is similar, which leads - ceteris paribus - to a lower skill premium and hence a less unequal distribution of income than in the LA scenario in the long run, whereas we observe an increase in income inequality in the initial stage of catching-up (the 'modified' Kuznets relationship). In a third scenario we allow for an even faster convergence process which results in a decreasing relative wage rate (the EA scenario). This scenario differs from the second scenario in that the building-up of a skilled labour force at a fast rate prevents the development of scarcity of skilled labour and thus keeps the skill premium low.

4.2 Setting up the simulations

Although the model is designed to include any number of factors, sectors and countries we show the simulations in a 2-2-2 framework. The simulations start in a long-run equilibrium (i.e. prices equal average unit costs and factor markets clear). For calculating this equilibrium the fixed parameters (i.e. the parameters not changing over time) are the parameters of the production function $a^c_{l,iz}, \sigma^c_{l,i}$, the parameters for the sourcing matrix $\tilde{a}^{cr}_{ij}, \alpha^{cr}_{A,ij}$ and $\sigma^c_{A,ij}$, the parameters for consumption demand $\beta^{cr}_i, \varsigma^r_i$, $\alpha_i, \beta_i, \alpha_0$ and γ_{ij}, and the exogenous mark-up ratios π^c_i. The parameters used are listed in table 4.1. Further there is a set of parameters which are changing exogenously over time, namely the total factor productivity $A^c_{l,i}$ and the weights of the two skill groups in the production function α^c_{iz}. For given wage rates w^c_{iz} the integrated equilibrium values of the other variables can be calculated. The output vector is normalized to $q^1_1 = 1.000$. Calculating the labour demand in this equilibrium and setting labour supply equal labour demand imposes factor market clearing.[7] The starting values of the variables are listed in table 4.2. Finally there is a set of parameter values which play a role in the dynamic adjustment processes (i.e. which feature in the set of differential equations) and thus in the evolution of the system. These parameters are listed in table 4.3. As one can see, the countries are equal with respect to all parameters with the exception of total factor productivity $A^c_{l,iz}$, the shares of skilled workers in the production function $\alpha^c_{l,iz}$ and the wage rates. We assume that sector 1 is the skill-intensive sector, which is also characterized by higher total factor productivity. Further, this sector also serves as the 'luxury' good in the expenditure system, i.e. expenditure shares for this sectors are rising with real income. Country B is the catching-up country. The initial gap in total factor productivity amounts to 30 per cent in the skill-intensive sector and 15 per cent in the low-skill-intensive sector. This results in a

[7]Numerical simulations for this model suggest that there is a one-one relationship between relative wage rates and factor endowments, which means that one could also start with a given endowment and calculate the equilibrium wage rates.

Variable	Country AC				Country CU			
	Sector and skill specific				**Sector and skill specific**			
	Sector 1		**Sector 2**		**Sector 1**		**Sector 2**	
	Skilled	**Unskilled**	**Skilled**	**Unskilled**	**Skilled**	**Unskilled**	**Skilled**	**Unskilled**
$a^c_{li,z}$	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Sector specific				**Sector specific**			
	Sector 1		**Sector 2**		**Sector 1**		**Sector 2**	
$\sigma^c_{l,i}$	1.100		1.100		1.100		1.100	
$\tilde{a}^c_{1i}$	0.400		0.100		0.400		0.100	
$\tilde{a}^c_{2i}$	0.100		0.400		0.100		0.400	
$\alpha^{cc}_{A,ji}, j = 1,2$	0.750		0.750		0.750		0.750	
$\alpha^{cr}_{A,ji}, j = 1,2$	0.250		0.250		0.250		0.250	
$\sigma^c_{A,ji}, j = 1,2$	2.500		2.500		2.500		2.500	
β^{cc}_i	0.750		0.750		0.750		0.750	
β^{cr}_i	0.250		0.250		0.250		0.250	
ς^c_i	2.500		2.500		2.500		2.500	
π^c_i	0.000		0.000		0.000		0.000	
	Global variables							
	Sector 1				**Sector 2**			
$\alpha_{AIM,i}$	0.500		0.500		0.500		0.500	
$\beta_{AIM,i}$	0.100		-0.100		0.100		-0.100	
$\gamma_{AIM,ji}, j = 1,2$	0.000		0.000		0.000		0.000	
	Economy wide							
$\alpha_{AIM,0}$	0.000							

Table 4.1: Parameter values

Variable	Country AC				Country CU			
	Sector and skill specific				Sector and skill specific			
	Sector 1		**Sector 2**		**Sector 1**		**Sector 2**	
	Skilled	**Unskilled**	**Skilled**	**Unskilled**	**Skilled**	**Unskilled**	**Skilled**	**Unskilled**
$\alpha^c_{l_i,z}$	0.667	0.333	0.333	0.667	0.583	0.417	0.298	0.702
$w_{i,z}$	0.667	0.333	0.667	0.333	0.563	0.187	0.563	0.187
$l_{i,z}$	0.185	0.185	0.130	0.597	0.178	0.412	0.107	0.917

Variable	Country AC		Country CU	
	Sector specific		Sector specific	
	Sector 1	**Sector 2**	**Sector 1**	**Sector 2**
$A^c_{l,i}$	1.000	0.800	0.700	0.680
p^c_i	1.962	1.868	1.930	1.527
r^c_i	0.000	0.000	0.000	0.000
m^c_i	0.000	0.000	0.000	0.000
j^c_i	0.000	0.000	0.000	0.000
f^{cc}_i	0.064	0.118	0.053	0.144
f^{cr}_i	0.017	0.039	0.022	0.049
q^c_i	0.185	0.294	0.178	0.343
g^c_i	0.000	0.000	0.000	0.000

Variable	Country AC		Country CU	
	Economy wide, skill specific		Economy wide, skill specific	
	Skilled	**Unskilled**	**Skilled**	**Unskilled**
l^c_z	0.315	0.783	0.285	1.329
h^c_z	0.315	0.783	0.285	1.329
u^c_z	0.000	0.000	0.000	0.000

Table 4.2: Starting values for variables and exogenously changing parameters

Parameter	**Country AC**		**Country CU**	
	Sector specific		**Sector specific**	
	Sector 1	**Sector 2**	**Sector 1**	**Sector 2**
$\delta^c_{p_i}$	0.100	0.100	0.250	0.250
$\kappa^c_{r_i}$	0.000	0.000	0.000	0.000
	Sector and skill specific		**Sector and skill specific**	
	Sector 1	**Sector 2**	**Sector 1**	**Sector 2**
	Skilled / **Unskilled**	**Skilled** / **Unskilled**	**Skilled** / **Unskilled**	**Skilled** / **Unskilled**
	Economy wide, skill specific		**Economy wide, skill specific**	
	Skilled	**Unskilled**	**Skilled**	**Unskilled**
$\kappa^c_{u_z}$	0.100	0.100	0.100	0.100
$\kappa^c_{w_z}$	0.010	0.010	0.010	0.010
$\gamma^c_{A_{i,pot}}$	0.100	0.100	0.100	0.100
$\gamma^c_{\alpha_{li,pot}}$	0.100	0.100	0.100	0.100
$\gamma^c_{h_{z,pot}}$				
Scenario 1	0.000	0.000	0.000	0.000
Scenario 2	0.050	0.050	0.050	0.050
Scenario 3	0.200	0.200	0.200	0.200

Table 4.3: Parameter values for dynamic equations

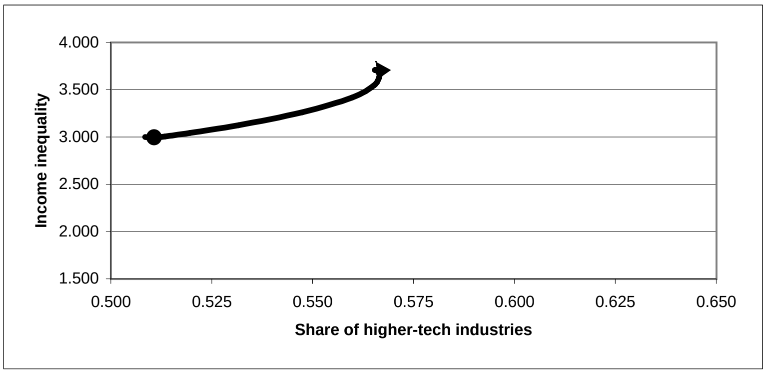
Gerschenkron pattern of catching-up in the simulations. In the case of two types of workers (as is assumed in the simulation model) the ratios $\alpha_{is}^c/(1-\alpha_{is}^c)$ for labour demand are determined. We set this ratio to 2 (0.5) for the skill-intensive (low-skill-intensive) sector in the advanced country and to 1.4 (0.425) for the catching-up country. Thus the gaps with respect to these ratios are the same as the gaps with respect to total factor productivity. Using these ratios the values for α_{iz}^c given in table 4.2 can easily be calculated.

These assumptions result in the following initial situation: The advanced country is relatively better endowed with skilled workers and is technologically relatively more advanced in the skill-intensive sector. Thus the comparative advantage in the skill-intensive sector stems from these two sources. On the other hand, it produces with a more skill-intensive technology which implies higher per unit costs (as skilled workers earn a higher wage rate); however, this does not lead to a reversion of the structure of comparative advantages (i.e. in terms of relative unit costs). The skill-intensive goods are relatively cheaper in the advanced country, which is mainly an effect of the relative endowment structure and the initial gaps. The advanced country thus specializes in the skill-intensive good with respect to production patterns. Further, as real income is higher in the advanced country, it also demands relatively more of the skill-intensive good due to the non-linear Engel curve effect.

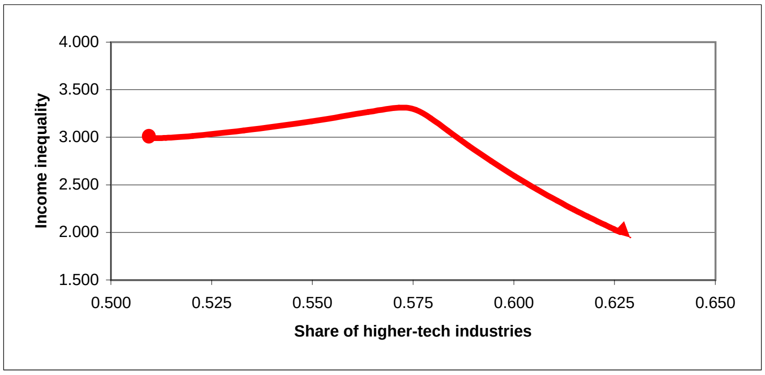
From this initial situation we simulate three patterns of convergence. We assume that country B is catching up in technology according to a logistic pattern given by $\dot{x}_{pot} = \gamma_x x_{pot}(1-x)$ where x refers to total factor productivity A_{li}^B and the ratio of shares $\alpha_{is}^B/(1-\alpha_{is}^B)$ with the inital value given by $x_{pot} = 0.001$. A similar specification is used for convergence in relative endowment structures. The simulations differ according to the parameter $\gamma_{h_z}^B$ as can be seen in table 4.3.

4.3 Simulation results

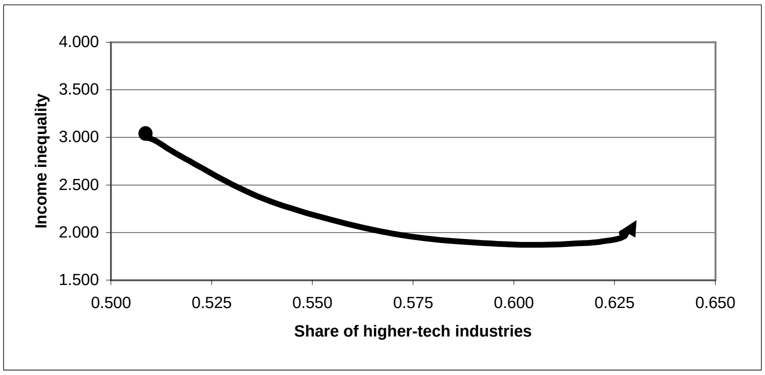
In this section we report the results of the simultion studies, which broadly confirm the patterns of the modified Kuznets hypothesis above. For the sake of brevity we restrict ourselves to presenting only the 'modified' Kuznets relationship emerging from the three scenarios (see figure 4.1) but we shall discuss the underlying dynamics of the other variables as well. Let us now report the results. First, there is a striking difference in the longer run between the scenario without relative factor endowment convergence (scenario 1) and scenarios 2 and 3 (with factor endowment convergence). Whereas in scenario 1 there is a divergence in relative wage rates, these are converging in scenarios 2 and 3. The reasons for the divergence in the first sceneario are clear: First, real income is rising as total factor productivity is rising and the relative price of the skill-intensive good is falling as total factor productivity is rising faster in this sector (the rise in skill intensity does not counteract this effect) which results in rising domestic demand for the skill-intensive good. Second, demand for the skill-intensive good from the advanced country AC (i.e. exports) are also rising relatively faster as (i) the relative price of the skill-intensive good is falling (i.e. attracting more demand from country AC) and (ii) real income is rising in country AC (due to lower prices of imports from country CU) which again shifts demand towards the skill-intensive good. Third, technology shifts to more skill-intensive



Scenario 1: No factor endowment convergence



Scenario 2: Slow factor endowment convergence



Scenario 3: Fast factor endowment convergence

Figure 4.1: The 'modified' Kuznets relationships

production, which increases demand for skilled workers (which dominates the effect on relative factor demand in spite of higher relative wages of skilled workers). All these aspects imply higher demand for skilled workers and higher demand for skill-intensive goods simultanously. This is exactly the pattern depicted in Figure 4.1, scenario 1. At the end of the simulation period the curve is even backward sloping. The reason for this is that, as the technological potential is exhausted, the adjustment processes in the labour market are not yet completed. One can see an ongoing rise in the relative wage rate of the skilled workers, which implies that country CU is losing competitiveness in the skill-intensive sectors, which results in a lower output share of the skill-intensive good.

Scenarios 2 and 3 differ with respect to the speed of convergence of relative factor endowments. Whereas in scenario 2 factor endowments converge more slowly than technology, we show in scenario 3 a situation where the 'human capital stock' is built up faster than technology convergence takes place. In both cases convergence with respect to relative prices and relative wage rates is observed. As in scenario 2 this takes place more slowly, there is a rise in income inequality and a rise in the relative output of the skill-intensive good (for the same reasons as discussed in scenario 1); in the longer run this tendency is counteracted by an increase in the relative endowment of skilled workers - and thus growing competitiveness in the skill-intensive sector - which results in the inverse U-shaped Kuznets relationship.

In scenario 3 the increase of the relative endowment of skilled workers decreases the relative wage rate of skilled workers and the relative price of the skill-intensive good, which implies higher domestic and foreign demand for the skill-intensive good and thus an upgrading of the industry structure. This is enforced by rising real incomes (due to technological change and a rising income of the unskilled workers, who can then afford to buy the skill-intensive good). Overall, this results in a downward sloping relationship between relative wage rates and industry upgrading.

5 Conclusions

In this paper we have shown that there may exist an inverse U-shaped relationship between the relative wage rates of skilled workers (which we use as a measure of income inequality) and the structure of the economy (in terms of the output shares of the skill-intensive industry) in the course of catching-up processes and trade integration. We have argued that the particular patterns of these two variables depend on the adoption of different development strategies: The first strategy relies on the importance of domestic demand patterns in the way that higher income inequality is needed for upgrading the industrial structure. However, as the relative wage rate of skilled workers is rising, this also means that competitiveness in the external market is decreasing and that this strategy thus has to go hand-in-hand with restrictions in trade.

The second strategy emphasizes the competitiveness effect in external markets and thus opts for measures which enable the skill-intensive industries in a country to produce at lower costs. In our model this was formulated by increases in the supply of skilled workers. Depending on the speed of skill-upgrading this may even result in a downward sloping relationship between income inequality and industry upgrading and is thus compatible with a liberal trade regime.

A Mathematical appendix

The investment goods demand vector is given by $\mathbf{j} = \mathbf{D}_j\mathbf{q}$ where $\mathbf{D}_j$ is a matrix with typical element $\sum_{s,j} \beta^{cs}_{J,ij}\nu^{rs}_{kj}m^r_k/p^c_i$. Inserting for $\beta^{cs}_{J,ij} = p^c_i a^{cs}_{ij}/c^s_j$ simplifies this element to $\sum_{s,j} a^{cs}_{ij}\gamma^{rs}_{kj}m^r_k/c^s_j$. A solution for the equilibrium balanced growth path in the global economy is that the total sum of profits (and rents) $\mathbf{m}^\top\mathbf{q}$ is allocated across countries and industries with $\nu^s_j = c^s_j q^s_j/\mathbf{c}^\top\mathbf{q}$. Inserting for γ^{rs}_{kj} yields $m^r_k \sum_{s,j} a^{cs}_{ij}q^s_j$. In a compact form the expression $\mathbf{D}_j\mathbf{q}$ can be rewritten as

$$\begin{aligned}
\mathbf{D}_j\mathbf{q} &= \left(\mathbf{c}^\top\mathbf{q}\right)^{-1}\left[\mathbf{m}^\top \otimes \begin{pmatrix} \mathbf{a}^\top_{1*}\mathbf{q} \\ \vdots \\ \mathbf{a}^\top_{N*}\mathbf{q} \end{pmatrix}\right]\mathbf{q} \\
&= \left(\mathbf{c}^\top\mathbf{q}\right)^{-1}(\mathbf{m}^\top \otimes \mathbf{A}\mathbf{q})\mathbf{q} \\
&= \frac{\mathbf{m}^\top\mathbf{q}}{\left(\mathbf{c}^\top\mathbf{q}\right)}\mathbf{A}\mathbf{q} \\
&= g\mathbf{A}\mathbf{q}.
\end{aligned}$$

The demand vector for consumption goods $\mathbf{f}$ can be represented by $\mathbf{D}_f\mathbf{q}$ where $\mathbf{D}_f$ has a typical element $\alpha^{cs}_i v^s_j/p^c_i$ with $\sum_{i,s}\alpha^{cs}_i = 1$.

We have to show that $\mathbf{q} = \mathbf{A}\mathbf{q} + g\mathbf{A}\mathbf{q} + \mathbf{D}_f\mathbf{q}$ has a nontrivial solution. This is a homogenous system of equations as $\mathbf{0} = (\mathbf{I} - \mathbf{A} + \mathbf{D}_j + \mathbf{D}_f)\mathbf{q}$. Premultiplying this equation with $\mathbf{p}^\top$ yields

$$\mathbf{p}^\top\mathbf{q} = (1+g)\mathbf{p}^\top\mathbf{A}\mathbf{q} + \mathbf{p}^\top\mathbf{D}_f\mathbf{q} = (1+g)\mathbf{p}^\top\mathbf{A}\mathbf{q} + (1+g)\mathbf{v}^\top\mathbf{q}.$$

Inserting for $g = \mathbf{m}^\top\mathbf{q}/\mathbf{c}^\top\mathbf{q}$ gives $\mathbf{p}^\top\mathbf{q} = \mathbf{c}^\top\mathbf{q}+\mathbf{m}^\top\mathbf{q}$ which is satisfied by definition. Thus there exists an output vector (for the balanced growth path) for which $(\mathbf{D}_j + \mathbf{D}_f)\mathbf{q} = (\mathbf{I} - \mathbf{A})\mathbf{q}$ is satisfied and the system has a nontrivial solution.

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